Some Factors Influencing the Productivity of Forest Soils

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ABSTRACT

The production of biomass is to a certain degree a direct expression of soil productivity. As trees store their annual growth from one year to another, it is usually more simple to obtain a relatively exact average evaluation of forest soil productivity than for cultivated soil.

Since 1954 in Norway, registrations of productive forest soil (annual normal increment of over 1.2 m^3/hectare/year) have been undertaken. A comparison of the numerical data for over 100,000 sample plots from more than 5 million hectares have been processed. The material has been used both for a quantitative examination of the influence of the individual soil forming factors on soil formation (solgenmetri) and to explain the soil factors' influence on productivity (solbonmetri).

Of over 116,000 evaluation sites from 5.417 million hectares, 11% had a total depth of soil material less than 20 cm, 34.8% between 20 and 70 cm, and 54.2% more than 70 cm. Approximately the tree growth is respectively 50% and 75% for the first and second depth class when the growth on the soil deeper than 70 cm is put at 100%. The frequency of unproductive areas (impediment) increases with decreasing soil depth, and the influence of soil depth on productivity is therefore greater than these figures indicate.

There is also a close relationship between profile type and growth. 80.1% of more than 107,000 examined sample plots from 5,024 million hectares were podzol, 12.5% brown earth, 2.3% transition forms between these two, and 5.1% were swamp soil. When the growth on brown earth is put at 100%, the transition forms have approximately 80%, podzol 60%, and swamp soil 50% of the brown earth. 3.318 million hectares of podzol were divided and 35.1% of these had A$_2$ horizon less than 3 cm thick, 29.6% 3—6 cm, 18.0% 6—10 cm, and 17.3% thicker than 10 cm. Generally speaking, the ticker the A$_2$ horizon the lower the productivity.

The production of biomass is, to a certain extent, a direct measure of soil productivity. In agriculture, yield is commonly used as an expression of productivity and in field trials yield difference is an indication of the effectiveness of a certain treatment—for example fertilizing.

Yield is a function not only of soil properties but also of climate. Variation in weather conditions, such as temperature and precipitation, can cause huge variations from one year to another at the same site. The yield for a certain treatment may also vary considerably. Thus, it is necessary to carry out field trials for many years in order to obtain reasonably reliable averages when one is working with herbaceous plants.

Trees store their growth increments from year to year so that it is usually simple to obtain relatively accurate figures for the mean annual production of forest biomass. In some ways, it is more simple to evaluate the factors influencing soil productivity in forestry than in agriculture.

A considerable number of forest soil observations have been made in connection with the work of the National Forest Survey in Norway since 1954. A comparison of numerical data from more than 100,000 sample plots representing more than 5 million hectares has been carried out. The recording of soil properties is relatively simple but the data are correspondingly voluminous. At the same evaluation sites where the soil properties were recorded other observations have also been made, *e.g.,* on mean annual growth. An attempt has been made to evaluate quantitatively the influence of individual soil forming factors (Lag 1961, 1968). For this branch of soil research, the term soli-genesimetri has been coined (abbreviated to solgenmetri).

The results of this research give opportunities to express the influence of different pedological factors on the productivity of an area. The term soli-bonitati-metri (abbreviated to solbonmetri) has been suggested for this kind of research.

A very large number of soil factors influence the productivity of forest soils. The following have been recorded in this survey : depth of soil material, texture, thickness of the humus horizon, block and stone content, geological nature of the parent material, and profile type. For some sample plots, information is available about soil moisture conditions as are the results of soil chemical analyses. Up to now we have got most information about the relationships between the influence of soil depth and profile type on productivity. These two properties will be considered in the following.

Over large areas of Norway, the bedrock is not covered by soil material. Where the hard country rock is bare or covered only by a thin soil mantle there is a growth impediment. Productive forest (normal increment of over 1.2 m^3/hectare/year) occurs only in areas where the rock is covered by soil material.

The forest soil is divided into depth classes of under 20 cm, 20—70 cm, and deeper than 70 cm. Of over 116,000 sample plots in the 5.417 million hectares of forest which have been investigated, 11 per cent are in the first depth class, 34.8 per cent in the second and 54.2 per cent in the third.

A shallower solum than normal gives reduced productivity potential. As these investigations are concerned only with productive forest sites, we can not give a complete account of the influence of reduction of the forest soil on the tree growth. With increasing depth of soil material the frequency of unproductive forest sites decreases (*i.e.,* increment less than 1.2 m^3/hectare/year). For the areas concerned in this investigation, the annual growth increment in the first depth class is about 50%, and in the second 75 per cent when the increment in the third depth class is set to 100 per cent.

The depth of soil material is essentially a prime consideration at the growth site. It is therefore clear that we are dealing with a simple casual relationship. The original soil depth has a direct influence on productivity.

In studying profile type in relation to productivity one must be aware of the relationship between profile development and other important growth factors for vegetation which obtain among the soil forming factors. It is, thus, more difficult to show the direct relationship between profile development and potential productivity than for soil depth and productivity. The correlation, however, can be just as interesting.

The profile type registration involved more than 107,000 sample plots spread over 4.024 million hectares. A division was made into the four main groups of podzol, brown earth, transition forms between these two, and swamp soil. Over most of the area under consideration the podzols were subgrouped on the thickness of the A_2 horizon: (1) less than 3 cm, (2) 3—6 cm, (3) 6—10 cm, and (4) thicker than 10 cm.

80.1 per cent of the observed sites were podzol, 12.5 per cent brown earth, 2.3 per cent transition forms, and 5.1 per cent were swamp soil. Of 3.318 million hectares of podzol, 35.1 per cent had A_2 horizon less than 3 cm thick, 29.6 per cent 3—6 cm, 18 per cent 6—10 cm, and 17.3 per cent thicker than 10 cm (Lag 1970).

There appears to be a close relationship between soil formation and tree growth. The brown earth is considerably more productive than the others although there are remarkable variations within this group. A number of results of chemical analyses of humus samples are available from the countries of Nord-Trondelag and Oppland (Lag 1962, 1968a). From these it appears that there is a wide range in variation in pH and base saturation in samples from brown earth. For the sake of accuracy, this group can be divided into several subgroups.

If the annual growth increment is put at 100 per cent for the brown earth, then the transition group is approximately 80 per cent, podzol 60 per cent, and swamp soil 50 per cent.

There is also a considerable variation within the three last groups. As a general rule it can be said that increasing thickness of the A_2 horizon is related to decreasing productivity although there are many exceptions.

Even by using such simple division as we have done, it is possible to make a number of conclusions. The evaluation of potential productivity for the different soils should be more easy being aware of such basic relationships.

Using a more detailed grouping, where more of the soil properties which can be observed in the field are taken into consideration, there should be greater possibilities for more precision in forest soil evaluation.

Laboratory investigations are of course useful, but these are as a rule relatively expensive. Even though analytical figures are not available for the site in question, the results of laboratory analyses can be of great value in deriving an expedient field classification.

In Norway we are continuing to work on the que
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REFERENCES

Läg, J. (1960) *Trans. 7th int. Congr. Soil Sci.* **5**, 21.

Läg, J, (1962) *Meddr norske Skogfors Ves.* **18**, 107.

Läg, J. (1968) *Acta Agric. scand.* **18**, 95.

Läg, J. (1968a) *Meddr norske Skogfors Ves.* **23**, 331.

Läg, J. (1970) *Landsskogtakseringen,* **50** (in the press).